

## Task Title: Predictive Maintenance for Industrial Equipment

### Scenario:

XSPACE TECHNOLOGIES Pvt Ltd is collaborating with a large manufacturing company that relies heavily on industrial machinery. Unexpected equipment failures have led to costly downtime and maintenance issues. The company wants to implement a predictive maintenance system that can predict when a machine is likely to fail, allowing for proactive maintenance scheduling.

You are tasked with analyzing the provided dataset, building a predictive model, and recommending strategies to minimize equipment downtime through timely maintenance.

### Objective:

1. Understand the factors that contribute to equipment failure.
2. Build a predictive model to forecast potential failures.
3. Provide actionable insights to optimize maintenance schedules and reduce downtime.

### Dataset:

You are provided with a CSV file containing the following columns:

- **Machine ID:** Unique identifier for each machine.
- **Timestamp:** The date and time when the data was recorded.
- **Temperature:** The operating temperature of the machine in degrees Celsius.
- **Pressure:** The pressure inside the machine in PSI (Pounds per Square Inch).
- **Vibration:** The vibration level of the machine in mm/s (millimeters per second).
- **Operational Hours:** The total number of hours the machine has been in operation.
- **Maintenance History:** A binary indicator (Yes/No) of whether the machine has undergone maintenance.
- **Failure:** A binary indicator (Yes/No) of whether the machine has failed.

### Tasks:

1. **Data Exploration and Preprocessing:**
  - Perform exploratory data analysis to understand the distribution and relationships between different variables.
  - Handle missing or inconsistent data and normalize or scale numerical features where necessary (e.g., Temperature, Pressure, Vibration).
  - Convert categorical variables, such as Maintenance History, into numerical representations.
2. **Feature Engineering:**
  - Create new features that might help in predicting failures, such as the average operating temperature, pressure fluctuations, or the total vibration over time.
  - Investigate the time-series nature of the data to detect trends and patterns that could lead to equipment failure.
3. **Model Development:**
  - Split the dataset into training and testing sets.
  - Develop a predictive model using algorithms like Random Forest, Support Vector Machine, or Gradient Boosting.
  - Fine-tune the model using cross-validation and evaluate its performance using metrics like accuracy, precision, recall, and the F1-score.
4. **Predictive Maintenance Strategy:**
  - Based on the model's predictions, design a maintenance strategy that includes scheduling maintenance before failures are likely to occur.
  - Suggest the optimal maintenance intervals and any additional measures the company should take to prevent unexpected failures.
5. **Visualization and Reporting:**
  - Create visualizations that show the relationship between the machine's operational parameters and its likelihood of failure.
  - Generate a detailed report summarizing your findings, model performance, and maintenance strategy recommendations.

### Tools Required:

- Python (Pandas for data manipulation, Scikit-learn for machine learning, Matplotlib/Seaborn for visualization)
- Jupyter Notebook or Google Colab for analysis and model development

### Expected Outcome:

- A preprocessed dataset with relevant features engineered for predictive modeling.
- A predictive maintenance model with strong performance metrics.
- A maintenance strategy that minimizes downtime and optimizes the use of resources.
- A comprehensive report with insights, visualizations, and actionable recommendations.

### Submission Guidelines:

- Submit your code, dataset, and report via a GitHub repository.
- Ensure that your notebook is well-documented, with comments explaining each step.
- The deadline for this task is **10-October-2024**.

## Evaluation Criteria:

- **Data Exploration and Preprocessing:** Quality of data handling and preparation.
- **Feature Engineering:** Creativity and relevance of new features.
- **Model Performance:** Accuracy and reliability of the predictive model.
- **Strategy and Reporting:** Practicality and effectiveness of the proposed maintenance strategy.